

IRD

Training

continuously

supports

your plant-wide

use of

IRD equipment

3 IRD Training Programs Cover All Phases of Machinery Vibration Analysis and Dynamic Balancing.

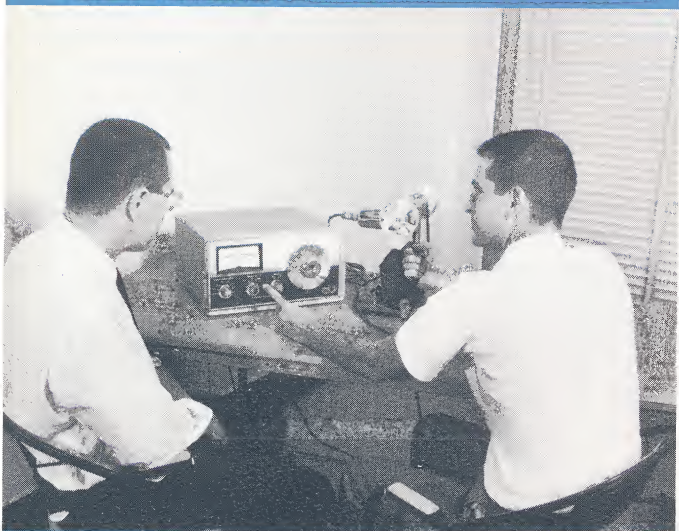
During the past 14 years IRD portable instruments have become industry's standard for vibration measurement, analysis and dynamic balancing — the positive KEYS to machinery condition.

All machinery vibrates. Excessive vibration is a warning that repairs may be required. Vibration analysis reveals which parts are defective and why.

To assure maximum results from the plant-wide application of your IRD equipment 3 training programs are available.



Sound movies cover vibration measurement, analysis and dynamic balancing as applied to the practical solution of machinery problems.



Supervised practical exercises, using your own IRD equipment, assure that basic fundamentals are remembered.

NATIONAL AUDIO-VISUAL TRAINING PROGRAM

A two-day comprehensive training course in the fundamentals of vibration analysis and dynamic balancing is conducted periodically in principal cities in the USA and Canada for IRD Customers.

Training is accomplished by a sound movie shown in four sections with practical exercises using your IRD equipment — all under the supervision of experienced IRD personnel. Instructors have a wide variety of first-hand knowledge on the practical solution to machinery problems.

Here is what the trainees learn:

- What vibration is
- What causes vibration
- How to pinpoint machinery problems
- How to apply the knowledge and techniques for plant-wide Engineered Maintenance.
- How to operate a vibration analyzer
- How to analyze vibration
- How to dynamically balance

A detailed, well-illustrated textbook keyed to the training film is provided for study and future reference on the job.

There is no charge for this training and as many men as you require may be trained both now and in the future.

TRAINING — A CONTINUOUS

ADVANCED TRAINING IN SHOP AND PRODUCTION BALANCING

This two-day session on new and advanced balancing methods is held each month at IRD's Worthington, Ohio, plant.

Prerequisite: National Audio-Visual Training Program

This program provides additional training in balancing procedures for a more thorough understanding of unbalance. A comprehensive textbook is included.

First Day

- Review basic balancing fundamentals
- Factors influencing balancing procedures
- Balancing computer methods
- In-place balancing
- Production Balancing

Second Day

- Balance tolerance
- Balancing flexible shafts
- Multiplane balancing
- Engine balancing
- General Discussion

Third Day (Optional) Individuals' special problems are analyzed with IRD's engineering staff. You are invited to bring prints or sample workpieces for consideration.

There is no fee. The only expense is for travel, meals and lodging.

ADVANCED TRAINING IN ENGINEERED MAINTENANCE

This two-day session on vibration measurement, analysis and interpretation as applied to plant-wide engineered maintenance is held each month at IRD's Worthington, Ohio, plant.

Prerequisite: National Audio-Visual Training Program

This program provides the essential information for you to organize an engineered maintenance program based on **VIBRATION—THE KEY TO MACHINERY CONDITION**. Special emphasis is put on vibration analysis techniques to detect and pinpoint problems on different type machines. A well-illustrated text is included.

First Day

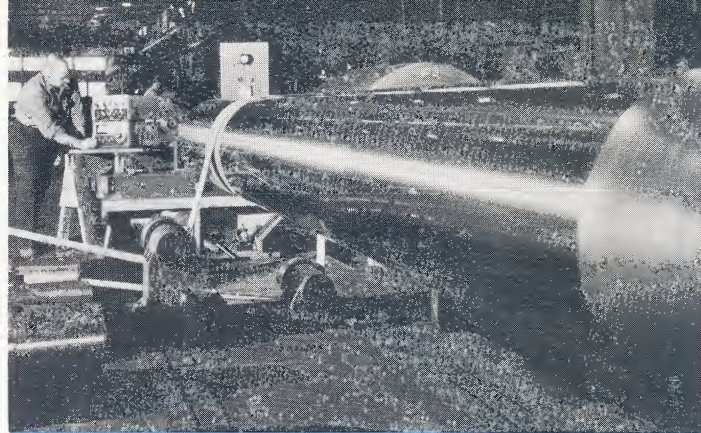
- Review — vibration analysis
- Organizing an Engineered Maintenance Control Program
- Initial vibration measurements
- Selecting periodic vibration check points
- Determining vibration tolerances

Second Day

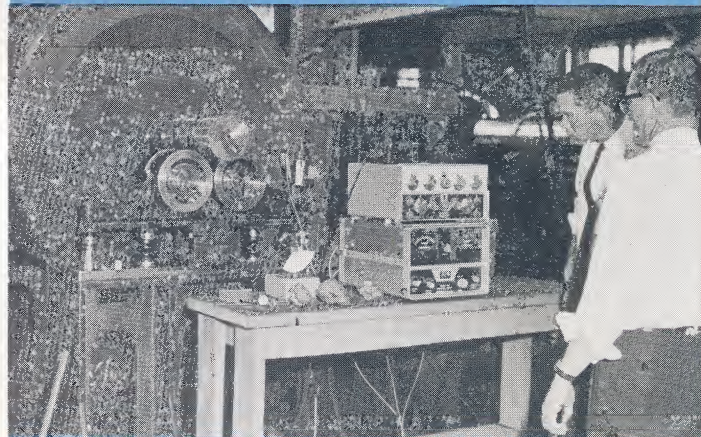
- Establishing periodic vibration check intervals
- Troubleshooting and balancing techniques
- Cause and effect of vibration on quality control
- Expanding the Engineered Maintenance Control Program

Third Day (Optional) — Vibration Symposium — a clearing house for exchanging ideas on positive engineered maintenance control.

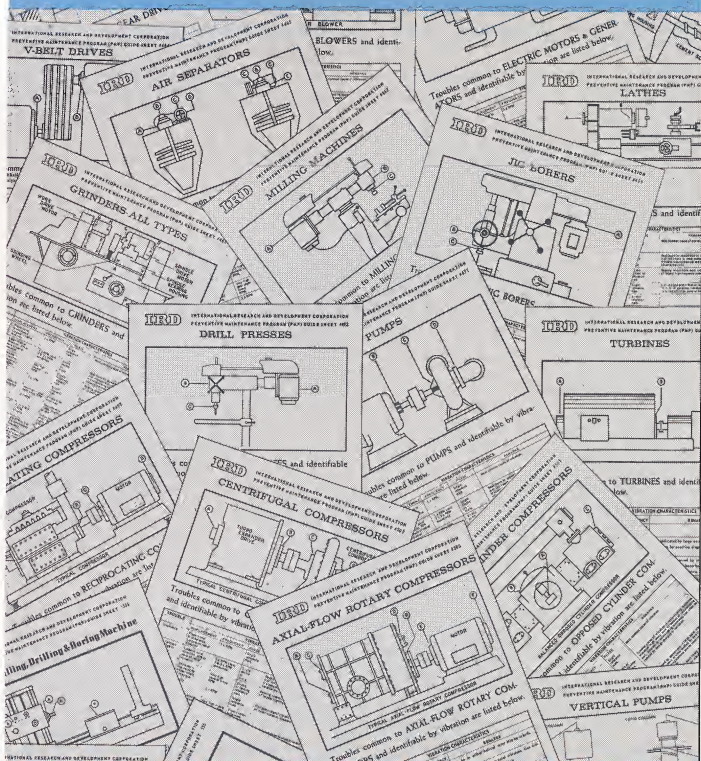
There is no fee. The only expense is for travel, meals and lodging.



Special topics such as flexible roll balancing, shown above, are covered in the IRD Advanced Training Program.



Balancing computer methods to speed in-place, job shop and production balancing are discussed and demonstrated in this training program.



Guide sheets, based on more than 14 years experience, are discussed in detail. They are your source of information on: vibration check points, troubles identified by vibration readings, and vibration tolerances.

IRD CUSTOMER SERVICE

for details contact your nearest IRD agent or District Office



INSTRUMENTS—MACHINES—KNOWLEDGE—INSTRUCTION

For Maintaining Efficient Productive Operation of Rotating Machinery



INTERNATIONAL RESEARCH AND DEVELOPMENT CORPORATION

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M MAINTENANCE

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March, 1966

Vibration analysis—maintenance moneysaver

Flexible ducting removes wood chips

Dust control study

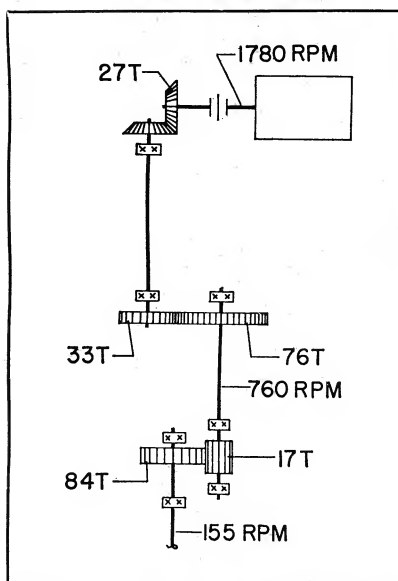
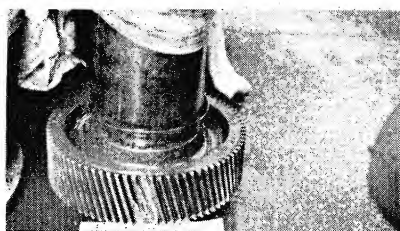


Figure 1.



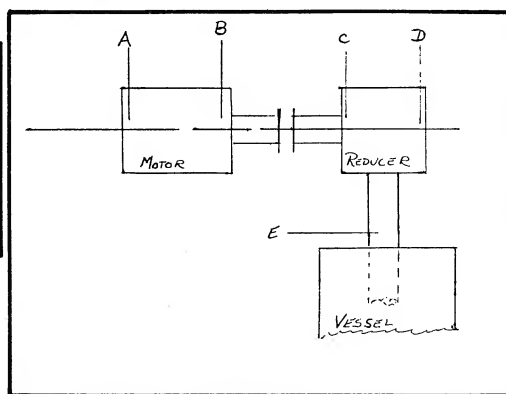
Extent of damage to teeth of gear shown.

VIBRATION HISTORY

DATE	JULY 5, 1963
MACHINE	
LOCATION	
NAME	
INSTRUMENT MODEL	600
S N	
OPERATOR	

LEGEND

SYM	IDENTIFIES
→	PICKUP POINT
X	PLAIN BEARING
X	BALL BEARING
— —	COUPLING



MACHINE SKETCH

		MACHINE SKETCH											
PICKUP POSITION	FILTER OUT		FILTER IN										
	MILS	CPM	MILS	CPM	MILS	CPM	MILS	CPM	IN/SEC	CPM	IN/SEC	CPM	
A	H	10-13	600	6-8	600	1.5	1780	.36	13000			.24	13000
	V	4	600	—	—	.4	1780	.34	13000			.24	13000
	A			6-10	600	.4	1780	.9	13000			.6	13000
B	H	7-10	600	3-4	600	.9	1780					.08	13000
	V	3	600	2-3	600	.25	1780	.24	13000			.15	13000
	A	8-10	600	3-5	600	.5	1780					.06	13000
C	H	6-8	600	4-7	600	.8	1780						
	V	VARIABLE		1.0	600	.08	1780						
	A	4-8	600	3.0	600	.3	1780						
D	H	7-8	600	4-6	600	1.5	1780						
	V	VARIABLE		—	—	—	—	.3	13000				
	A	6-7	600	4-6	600	.5	1780						
E	H			1.0	600			.18	13000				
	V							.28	13000				
	A												

H - HORIZONTAL V - VERTICAL A - AXIAL

Figure 2.

Vibration Analysis—Maintenance Moneysaver

Vibration analysis can serve in many directions as a tool for maintenance. It provides a check-out and acceptance for new equipment, a reduction of down time for repairs, and a part of a preventive maintenance program. Each of these makes a return on the original capital investment.

by **RICHARD L. POLING**
Maintenance Engineer
Marbon Chemical Div.
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Washington, W. Va.

In the start-up of new equipment, vibration analysis can be a valuable aid in evaluation of the equipment while under warranty

and also in establishing a record for later use. In cases where the equipment will not pass the acceptance test, the manufacturer will be requested to replace it with equipment in good operating condition. Manufacturers at times may redesign their equipment as a result of the original inspection.

Figure 4. →

Currently, manufacturers are updating their equipment by vibration checks prior to shipping or they will send vibration data. An example of this exploration of new equipment is given in Figs. 1 through 4, involving a gear reducer. In the illustrations, you will note the input rpm of 1750 with 27 teeth, the intermediate shaft rpm of 760 with 33 and 76 teeth, and the low speed shaft rpm of 155 with 17 and 84 teeth. Vibration sequences are:

1. 600 CPM
2. 1,780 CPM
3. 9,000 CPM
4. 13,000 CPM

Vibrations occurring at 600 cycles/minute are caused by hydraulic forces within the vessel. You will further note this vibration varies from 1.0 to 10.0 mils in amplitude (1 mil equals .001" peak to peak displacement).

Vibrations occurring at 1780 cycles/minute are caused by the motor.

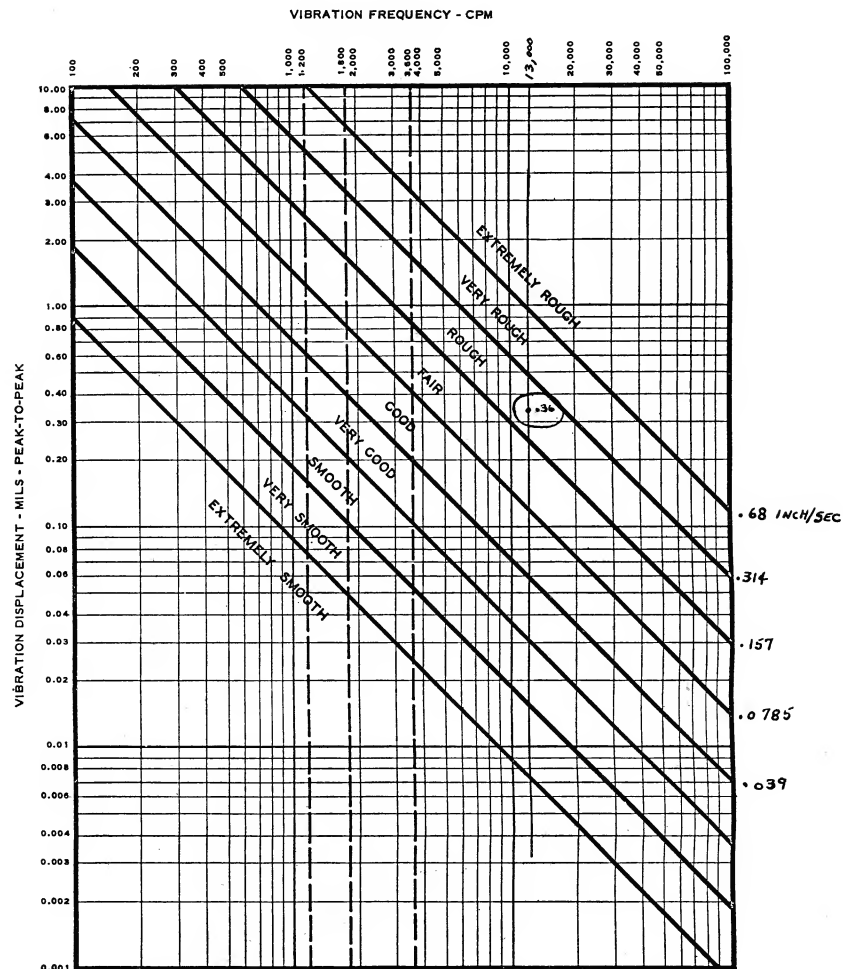
The vibration occurring at 9000, which does not show on this unit, was found in another unit to be caused by rough balls in the low speed pinion bearing (11 balls x 760 rpm equals approximately 9000 CPM).

At 13,000 cycles/minute the vibration was caused by the low speed gear damage (84 teeth x 155 rpm equals 13,000 CPM).

This analysis revealed that the low speed gear was failing. The manufacturer replaced the gearing with new gears until completion of the study of the premature failure. They found out that their gears were designed with a low service factor and as a result the hardness of the steel was insufficient. This caused them to redesign their gear reducer. After redesign the vibration level varied between .07 and .15 mils.

Many manufacturers will supply vibration data if requested at time

GENERAL MACHINERY VIBRATION SEVERITY CHART

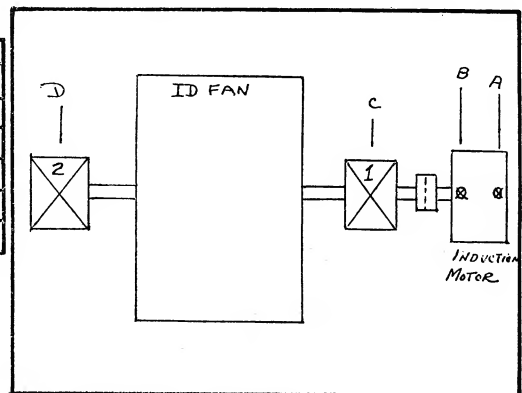


VIBRATION HISTORY

DATE	SEPT 8, 1962
MACHINE	
LOCATION	
NAME	
INSTRUMENT MODEL	600
S N	
OPERATOR	

LEGEND

SYM	IDENTIFIES
→	PICKUP POINT
×	PLAIN BEARING
⊗	BALL BEARING
— —	COUPLING



MACHINE SKETCH

PICKUP POSITION	FILTER OUT (PRIOR)				FILTER IN (AFTER)							
	MILS	CPM	MILS	CPM	MILS	CPM	MILS	CPM	IN/SEC	CPM	IN/SEC	CPM
A H			3.2	900			.7	900				
A V			2.5	900			.45	900				
A A			1.5	900			.6	900				
B H			5.3	900			1.0	900				
B V			2.4	900			.7	900				
B A			1.9	900			1.0	900				
C H	50	900	50	900			.9	900				
C V			10	900			.5	900				
C A			3.2	900			.59	900				
D H	23	900	23	900			.9	900				
D V			.5	900			.5	900				
D A			2.5	900			.65	900				

H - HORIZONTAL V - VERTICAL A - AXIAL

Figure 5.

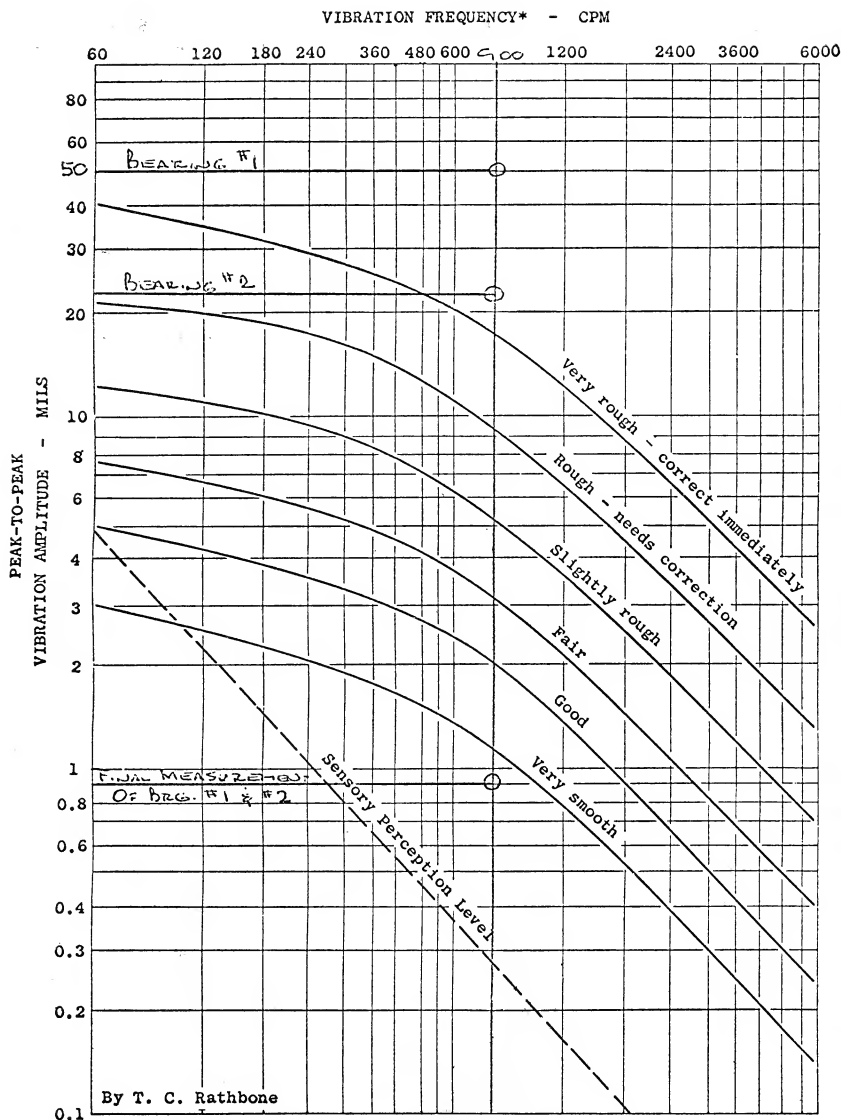


Figure 6.

of purchase although this phase is still in its infancy.

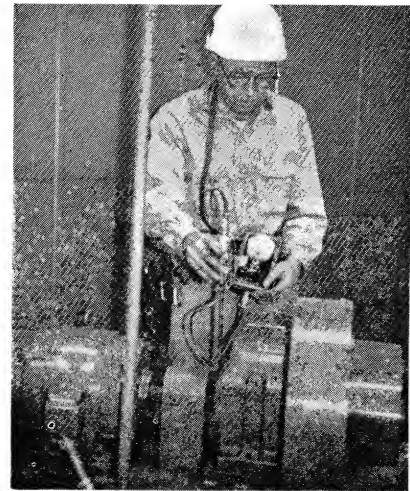
A complete analysis is made of equipment and data resolved in the piece (bearing, gear, belt, sprocket, etc.) that is causing the various frequencies of vibration. Depending upon the amplitude and frequency of vibration on the General Machinery Severity Chart, (See Fig. 4), a decision is made in regard to how long the equipment can run without severe damage. This allows maintenance and production to establish a downtime schedule. Repair parts that may not be on hand for repairs are obtained for the shutdown. With this approach, planning and scheduling of equipment results in minimum loss of production. This can best be illustrated by example of an induced draft fan.

The fan had been inspected six months previously, indicating the wear plates would have to be replaced on the rotor. During the time interval, periodic vibration checks were made. Evidence indicated that the bearings in the motor were beginning to approach failure.

Previous outages required two weeks down time due to housing removal and for an outside vendor to balance the rotor. This time the fan rotor was repaired and balanced in place. Total down time was five days versus two weeks.

Notice that only two readings are available as an initial point. (Fig. 5). Horizontal on inboard bearing, point C; and out-board bearing, point D.

The second set of readings was



Portable, battery-powered vibration analyzer may be used for periodic readings.

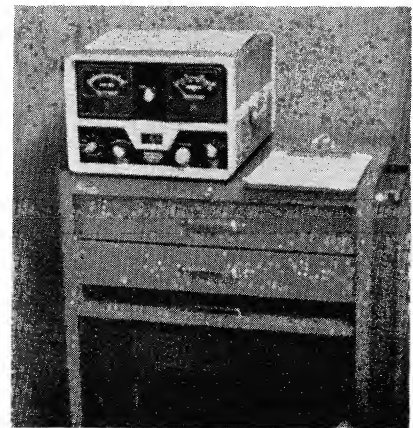


Fig. 8. Vibration Analyzer Cart.

taken with the filter in prior to any trial weights.

The third set of figures was the final reading. This was not a single step balance operation.

Figure 6, the Rathbone Chart shows the initial and final readings giving a visible picture of the vibration level. To balance this fan from 23 to 50 mils to .9 mil required 51 ounces of weight on the periphery of #2 side.

Vibration analysis should be a part of efficient preventive maintenance. Keep in mind that the trend in preventive maintenance is no longer a dismantle and overhaul schedule, but to use tools that can tell you whether there is trouble that needs to be corrected.

One of these tools, as mentioned previously, is the vibration analyzer. For example, a portable battery-powered instrument (above) might be used in periodic vibration readings. This periodic vibra-

VIBRATION IDENTIFICATION

Figure 9.

CAUSE	AMPLITUDE	FREQUENCY	PHASE	REMARKS
Unbalance	Proportional to unbalance. Largest in radial direction.	1 x RPM	Single reference mark.	Most common cause of vibration.
Misalignment couplings or bearings and bent shaft	Large in axial direction 50% or more of radial vibration	1 x RPM usual 2 & 3 x RPM sometimes	Single double or triple	Best found by appearance of large axial vibration. Use dial indicators or other method for positive diagnosis. If sleeve bearing machine and no coupling misalignment balance the rotor.
Bad bearings anti-friction type	Unsteady - use velocity measurement if possible	Very high several times RPM	Erratic	Bearing responsible most likely the one nearest point of largest high-frequency vibration..
Eccentric journals	Usually not large	1 x RPM	Single mark	If on gears largest vibration in line with gear centers. If on motor or generator vibration disappears when power is turned off. If on pump or blower attempt to balance.
Bad gears or gear noise	Low - use velocity measure if possible	Very high gear teeth times RPM	Erratic	
Mechanical looseness		2 x RPM	Two reference marks. Slightly erratic.	Usually accompanied by unbalance and/or misalignment.
Bad drive belts	Erratic or pulsing	1, 2, 3 & 4 x RPM of belts	One or two depending on frequency. Usually unsteady.	Strob light best tool to freeze faulty belt.
Electrical	Disappears when power is turned off.	1 x RPM or 1 or 2 x synchronous frequency.	Single or rotating double mark.	If vibration amplitude drops off instantly when power is turned off cause is electrical.
Aerodynamic hydraulic forces		1 x RPM or number of blades on fan or impeller x RPM		Rare as a cause of trouble except in cases of resonance.
Reciprocating forces		1, 2 & higher orders x RPM		Inherent in reciprocating machines can only be reduced by design changes or isolation.

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tion plan could be called "predictable maintenance." Vibration data on bearings, couplings, excessive wear of parts (looseness), and alignment can be checked at any time with predictable maintenance. This PM is performed on daily, weekly, monthly, quarterly, six month or a yearly basis.

When vibration approaches or begins to exceed a pre-established tolerance, trouble is indicated. The mechanic also passes along information any time the vibration level has a definite increase. This information is received by the maintenance foreman who also checks the particular piece of equipment. After this, production is contacted to obtain data in regard to equipment shutdown and then contacts the maintenance engineering section. A maintenance engineer investigates the vibration using a portable instrument or the complex vibration analyzer (Figure 8). This cart contains extension cords, wall plug adapters, extra pickups, switches, vise grips, and data sheets plus any other equipment that may be

needed for a complete analysis.

The question might be asked, how and where do you arrive at the pre-established tolerances? This is self-planned analysis, plus useful information such as IRD (International Research and Development) preventive maintenance program recommendations. This type of program acts as a guide in general but the actual tolerances are subject to: how critical the equipment is to production; the length of the delivery date of repair parts; and, whether auxiliary equipment is available while the unit would be out of service for repairs.

If a complete analysis is made on the equipment, the vibration data is resolved to what is causing the highest vibration (bearings, gears, belt, sprockets, etc.). Depending upon the amplitude and frequency of vibration upon the General Machinery Severity Chart (Fig. 4), a decision is made as to how long the equipment can run without severe damage. This allows production and maintenance time to re-schedule.

Another question might involve equipment running in adverse conditions twenty-four hours a day. This type of service lowers the pre-established level. Since the level is lower, contamination is usually found to be the cause of failure; however, the vibration still follows a definite pattern.

From a paper presented at the 16th Plant Engineering & Maintenance Conference.

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